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Artificial intelligence in road traffic accident prediction

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ABSTRACT. The rapid development of AI shows its power and great development potential in practical engineering applications. Critical issues and potential solutions can reduce road traffic accidents and application of AI in road accident prediction. The published use of AI for road accident prediction is reviewed, presented, and represented as the main objective. The methods are collecting article data, quotations, presentation, and representation. The article data collection was obtained from 671 conference and journal articles in 2019-2023, but the suitability of articles that can be used is 69. Quotation produces a grouping of approaches, models, predictions, and benefits. The presentation showed that most approaches used were machine learning, the most used model was random forest, the prediction was mostly about severity, and the most benefit was about number reduction. Representation produces road accidents and related factors into factors in road accident predictions using artificial intelligence, so strategies and anticipation can be made to overcome them to improve road safety. AI in road accident prediction plays an important role in building predictive models with the hope that road accidents can be identified early, risk factors can be reduced, and effective preventive measures can be taken to improve road safety.

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INTRODUCTION

Advanced computer technologies such as big data, Artificial Intelligence (AI), cloud computing, digital twins, and edge computing have been applied in various fields along with advances in digitalization(Lv & Xie, 2021). AI is essential in many real-world applications (Yuan et al., 2021) with inconsistent and affected data (Tonni et al., 2021). AI can offer emergency situational awareness and increase the efficiency of emergency response operations (Barachi et al., 2020). AI presents unprecedented prospects for improving the performance of various industries and companies (Khan et al., 2022). AI can accurately analyze locations based on potential risks (Meocci et al., 2021). Each AI algorithm uses a different model and makes predictions based on features (Kumar et al., 2021).

Actualized AI can improve Intelligent Transportation Systems (ITS) (Lv & Xie, 2021) to monitor and investigate large amounts of data generated in transportation (Shaheen et al., 2020). Safety and emergency systems with an AI approach can provide public security by providing economical and reliable transportation (Gangwani & Gangwani, 2021). Transportation using AI focuses on transportation management (Khan et al., 2022) and accident avoidance (Huamaní et al., 2023). Face detection is performed to warn drivers about drowsiness or to avoid road accidents (Kshirsagar et al., 2022). Road accident-prone points are predicted using AI using the spatial grouping and cumulative frequency curve methods (Yuan et al., 2021). AI exploration in facilitating automatic incident detection systems is used to reduce road accidents (Olugbade et al., 2022). Proactive accident prevention will evaluate the risk of road accidents in real-time using AI (Kim et al., 2021) and is a key aspect of road safety (Tonni et al., 2021). AI enables road accidents to be predicted and prevented (Olayode et al., 2020; Oueida et al., 2022). Investigation of the stability and efficiency of AI techniques for reducing road accidents (Olugbade et al., 2022). With proper implementation, an AI-enabled road accident management system can save millions of lives (Panda et al., 2023).

Road accidents have become more dangerous, the highest cause of death (Kumar et al., 2021), and involve a very relevant economic dimension (Infante et al., 2023). Road accident handling is done by intelligently identifying vehicle speed (Ji et al., 2023), tracking, and penalizing (Franklin & Mohana, 2020). Predicting accidents requires stakeholders to create strategies and anticipate the worst possibilities. These requirements have been widely investigated using several technologies and approaches. AI is important in answering these needs because of its reliability, speed, and high accuracy. Identifying and reviewing the use of AI, which is still lacking, is an obstacle in developing AI to predict road accidents. Representation of road accident predictions using AI is an achievable goal. Representations are obtained based on road accident presentations from articles selected and collected first. The resulting presentations and representations can be the basis for developing and utilizing AI in predicting road accidents so that it can support strategies and anticipation to achieve high road safety.

METHODS

The stages carried out include the collection of article data, quotation, presentation, and representation (Figure 1). Collecting article data is the stage of collecting conference and journal articles published in 2019-2023 with the keyword "road accident prediction using artificial intelligence" via the Mendeley website (https://www.mendeley.com/search/). Sorting and selecting articles based on keywords corresponding to the title and abstract but not for articles indicated as fake or unclear. 3 Authors act as reviewers who review and discuss appropriate and inappropriate articles. Suitable articles include approaches to using AI, using AI models, types of road accident predictions, and the benefits of road accident predictions. Collecting and storing appropriate articles is the result of the collection of article data stage.

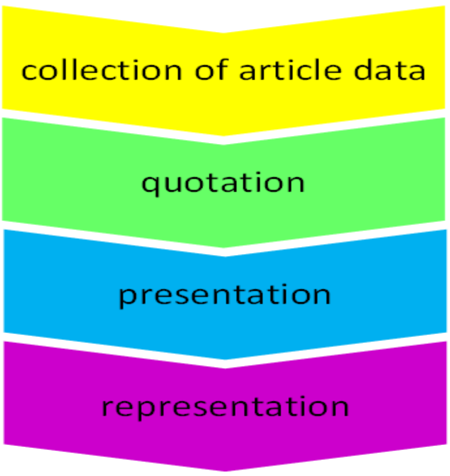

Figure 1. Research stages

Quotation is the next stage, providing a quote for each article. The four quotes embedded in each article are approach, model, prediction, and benefit. Each type of quote is studied, explored, researched, and searched throughout the article. The results achieved at the quotation stage are a quotation map for articles about road accident predictions using artificial intelligence containing quotes. Presentation is carried out by presenting the data from the quotation stage. The data presented includes the distribution of each type of quotation produced. The results that must be obtained are the presentation of artificial intelligence used to predict road accidents based on quotations: approach, model, prediction, and benefits. Representation results are obtained based on a presentation describing AI's role in road accident prediction. The description of road accident predictions is reflected in aspects that surround or are connected so that the predictions can support the goals to be achieved. The results of the depiction can be used as a basis for developing future road accident predictions using AI.

Results and Discussion

The concept of positive feedback cycles and continuous improvement in AI systems is called the Artificial Intelligence (AI) Flywheel. The flywheel inspired the concept, which is about a mechanism that stores rotational energy and builds momentum as it spins faster. The concept of a flywheel in the context of AI describes a feedback loop that accelerates the capabilities and benefits of AI over time. AI flywheel chooses the right problem, data collection and preprocessing, model construction, model deployment, and continuous monitoring.

The right problem involves selecting the most relevant and impactful problems using AI techniques. Organizations can ensure that AI initiatives have a meaningful impact, generate valuable insights, and contribute to the overall success of the AI flywheel by selecting the right issues.

Collection and processing involves gathering relevant, high-quality data and preparing it for use in developing AI models. Collecting and processing the right data in an AI flywheel is important to ensure that the developed AI model can access quality and well-structured data. Good data is an important foundation for producing accurate, effective, and reliable AI models.

Model construction involves developing and training an AI model that will be used to make predictions, make decisions, or solve the problem you want to solve. The trained AI model can be used in practical implementations to make predictions or solve the intended problem after complete model construction. Model construction is a central stage in AI flywheels that enhances AI capabilities and the positive feedback cycle.

The AI model that has been constructed and trained will be implemented in a production environment or a real application in the deployment model. The use of ready-to-engage AI models to make predictions, make decisions, or solve problems you want to solve. The deployment model allows AI models to be developed to provide real benefits and provide solutions to the problems you want to solve. An AI model that is implemented effectively in a production environment can continuously evolve and generate sustainable benefits.

Continuous monitoring involves monitoring and evaluating the performance of AI models that have been implemented in production environments. Continuous monitoring enables early detection of problems, improvement of performance, and taking necessary actions to maintain the reliability and effectiveness of AI models. Continuous monitoring ensures that the AI model performs well, is relevant, and provides the expected benefits. Continuous monitoring, improvements, and adjustments can be made proactively, driving the continuity and success of AI implementation. The AI flywheel concept emphasizes the importance of continuous learning, feedback, and iteration to drive AI progress. If the system gains momentum and capability, it can positively impact health, finance, transportation, and many more (Figure 2).

The road accident prediction development and adjustment cycle is based on the AI flywheel concept. The demand for road accident predictions using AI will continue to grow and must be answered. The developments carried out can be searched for and explored from published articles. The number of articles collected was 671 conference and journal articles published in 2019-2023, but only 69 articles were suitable and usable. The 69 articles were obtained from screening road accident prediction models that use AI. The article's results are given a quotation consisting of approach, model, prediction, and benefits (Table 1).

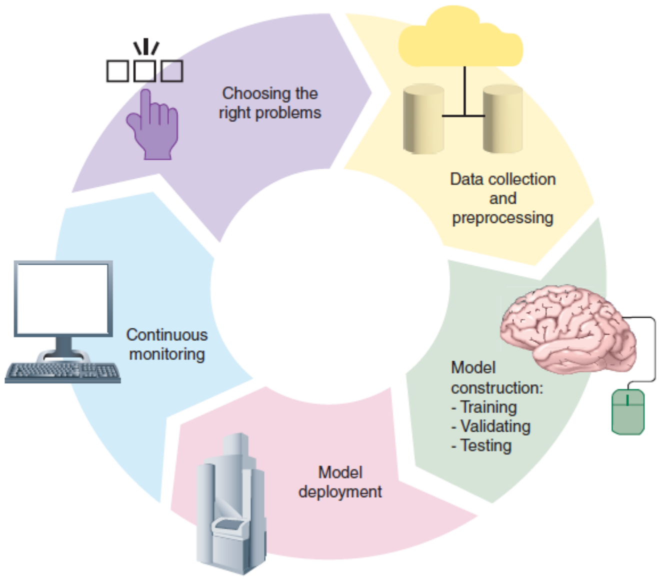

Figure 2. Artificial intelligence flywheel (Farina et al., 2022).

Table 1. Article quotation

Approach	Model	Prediction	Benefit
1. Deep learning (Alrajhi & Kamel, 2019; Behura & Behura, 2020; Gutierrez-Osorio & Pedraza, 2020; N & Punithavalli, 2020; Ning et al., 2022; Pachaivannan et al., 2020; Shaik et al., 2021; Singh et al., 2020) 2. Machine Learning (Alagarsamy et al., 2021; Augustine & Shukla, 2022; Babu & Tamilselvi, 2019; Bahiru et al., 2023; Ballamudi, 2019; Becker et al., 2020; Begum, 2022; Bokaba et al., 2022; Boo & Choi, 2021, 2022;	1. Adaptive Boosting (AdaBoost) (Ballamudi, 2019; Bokaba et al., 2022; Dabhade, 2020) 2. Apriori (N & Punithavalli, 2019) 3. Artificial Neural Networks (ANN) (Pachaivannan et al., 2020; Prakash & V, 2022; Radzuan et al., 2020; Yeole et al., 2022, 2023) 4. Association Rule (AR)(S et al., 2022) 5. AutoRegressive Moving Average with eXogenous (ARMAX)(Borucka et al., 2020) 6. Back-Propagation Neural Network(BPNN)(Guo et al., 2022; Wu & Wang, 2020; Xiao et al., 2020) 7. Bayesian Network (BN)(Lu et al., 2022) 8. Biological Neural Networks (BNN)(Pachaivannan et al., 2020) 9. Boosting (Joshi et al., 2020) 10. Categorical Naive Bayes(CNB) (Paul et al., 2020) 11. Classification and Regression Trees (CART)(Dia, Faty, Sall, et al., 2022; Jha et al., 2021) 12. Convolutional Neural Network (CNN)(Pachaivannan et al., 2020; Shaik et al., 2021) 13. Decision Tree (DT)(Augustine & Shukla, 2022; Bahiru et al., 2023; Ballamudi, 2019; Budiawan et al., 2022; Chen et al., 2022; Dabhade, 2020; Donchenko et al., 2020; Gutierrez-Osorio & Pedraza, 2020; Jain et al., 2022; Mane & Rathod, 2022;	1. Accuracy(Prakash & V, 2022; Wu & Wang, 2020) 2. Architecture(Lazar & Jarir, 2022) 3. Causes(Babu & Tamilselvi, 2019; Behura & Behura, 2020; Bokaba et al., 2022; Gutierrez-Osorio & Pedraza, 2020; Parthiban et al., 2022; Sahu et al., 2023; Sundari et al., 2023; Yeole et al., 2023) 4. Characteristics(Boo & Choi, 2022) 5. Critical(Pachaivannan et al., 2020) 6. Death(Alrajhi & Kamel, 2019) 7. Economic(M. H. Yuan & Wu, 2022) 8. Effects(Bokaba et al., 2022) 9. Efficient(N & Punithavalli, 2020; Yeole et al., 2022) 10. Frequency(Popoola et al., 2019)(Singh et al., 2020) 11. Incidence(Paul et al., 2020) 12. Influence(Chen et al., 2022)	1. Accurate Decision(Augustine & Shukla, 2022; Bahiru et al., 2023; Dabhade, 2020; Guo et al., 2022; Lu et al., 2022; Paul et al., 2020; Prakash & V, 2022; Venkat et al., 2020) 2. Comparison of Performance(Augustine & Shukla, 2022; Boo & Choi, 2022; Whasphutthisit & Jitsakul, 2022; Wu & Wang, 2020) 3. Contribution Factors(Charandabi et al., 2022; Chen et al., 2022; Dias et al., 2023; Gutierrez-Osorio & Pedraza, 2020; Kushwaha & Abirami, 2022; Lazar & Jarir, 2022; Lu et al., 2022; Mane & Rathod, 2022; Mapa, 2019; Ning et al., 2022; P & M, 2022; Popoola et al., 2019; Rajkumar et al., 2020; Yassin & Pooja, 2020; Yeole et al., 2023) 4. Control(Alagarsamy et al., 2021; Babu & Tamilselvi, 2019; Becker et al., 2020; Dia, Faty,

Approach	Model	Prediction	Benefit
Borucka et al., 2020; Budiawan et al., 2022; Charandabi et al., 2022; Chen et al., 2022; Cheng et al., 2019; Dabhade, 2020; Dia, Faty, Sarr, et al., 2022; Dias et al., 2023; Donchenko et al., 2020; Fiorentini & Losa, 2020; Gorzelańczyk et al., 2022; Guo et al., 2022; Gupta et al., 2022; Jain et al., 2022; Jha et al., 2021; Joshi et al., 2020; Kaliraja et al., 2022; Kandasamy et al., 2021; D. Kim et al., 2021; H. Kim et al., 2022; Kushwaha & Abirami, 2022; Lazar & Jarir, 2022; Lu et al., 2022; Mapa, 2019; Mehta et al., 2022; Mor et al., 2020; N & Punithavalli, 2019; P & M, 2022; Panda et al., 2023; Parthiban et al., 2022; Patil et al., 2021; Paul et al., 2020; Popoola et al., 2019; Prakash & V, 2022; Radzuan et al., 2020; Rajkumar et al., 2020; S et al., 2022; Sahu et al., 2023; Sundari	Mapa, 2019; N & Punithavalli, 2020; Paul et al., 2020; Venkat et al., 2020) 14. Deep Neural Network (DNN)(Dias et al., 2023; N & Punithavalli, 2020; Pachaivannan et al., 2020; Singh et al., 2020) 15. Enhanced Expectation-Maximization (EEM) (Babu & Tamilselvi, 2019) 16. Exponential Equalization (EE)(Gorzelańczyk et al., 2022) 17. Extra-Trees (ET)(Boo & Choi, 2022) 18. Extreme Gradient Boosting(XGBoost)(Augustine & Shukla, 2022; Boo & Choi, 2022; Donchenko et al., 2020; D. Kim et al., 2021; Mehta et al., 2022; Panda et al., 2023) 19. Fuzzy Neural Network (FNN)(Zhao et al., 2020) 20. Generalized Regression Neural Network (GRNN)(Charandabi et al., 2022) 21. Gradient Boosting Machine (GBM)(Panda et al., 2023) 22. Holt-Winters(Borucka et al., 2020) 23. K-Means(Yassin & Pooja, 2020)(P & M, 2022)(Patil et al., 2021) 24. K-Nearest Neighbours (KNN)(Augustine & Shukla, 2022; Ballamudi, 2019; Bokaba et al., 2022; Dabhade, 2020; Dia, Faty, Sarr, et al., 2022; Fiorentini & Losa, 2020; Jha et al., 2021; Lazar & Jarir, 2022; Parthiban et al., 2022; Prakash & V, 2022; Sahu et al., 2023; Whasphutthisit & Jitsakul, 2022) 25. Linear Discriminant Analysis (LDA)(Jha et al., 2021) 26. Logistic Regression (LR(Augustine & Shukla, 2022; Babu & Tamilselvi, 2019; Becker et al., 2020; Bokaba et al., 2022; Boo & Choi, 2021; Dia, Faty, Sarr, et al., 2022; Fiorentini & Losa, 2020; Jha et al., 2021; Lazar & Jarir, 2022; Mane & Rathod, 2022; Mor et al., 2020; Rajkumar et al., 2020; S et al., 2022; Venkat et al., 2020; M. H. Yuan & Wu, 2022) 27. Long Short-Term Memory (LSTM)(Alrajhi & Kamel, 2019) 28. Multilayer Perceptron (MP)(Paul et al., 2020) 29. Naïve Bayes (NB)(Bahiru et al., 2023; Ballamudi, 2019; Bokaba et al., 2022; Dabhade, 2020; Dia, Faty, Sarr, et al., 2022; Jha et al., 2021; Lazar & Jarir, 2022; Mane & Rathod, 2022; S et al., 2022) 30. Negative Binomial (NB)(Popoola et al., 2019) 31. Neural Network (NN)(D. Kim et al., 2021; Sundari et al., 2023; Whasphutthisit & Jitsakul, 2022) 32. Ordered Logistic (OL) (Popoola et al., 2019)	13. Injury(Alrajhi & Kamel, 2019; Ballamudi, 2019; Boo & Choi, 2021; Dabhade, 2020; Radzuan et al., 2020; Shaik et al., 2021) 14. Location(Alagarsamy et al., 2021; Gupta et al., 2022; Joshi et al., 2020; N & Punithavalli, 2019; Patil et al., 2021) 15. Mockup(S et al., 2022) 16. Modelling(Venkat et al., 2020) 17. Number(Becker et al., 2020; Behura & Behura, 2020; Borucka et al., 2020; Cheng et al., 2019; Gorzelańczyk et al., 2022; Guo et al., 2022) 18. Patterns(Chen et al., 2022) 19. Performance(Whasphutthisit & Jitsakul, 2022) 20. Potential(Augustine & Shukla, 2022)(Mane & Rathod, 2022) 21. Rate(P & M, 2022)(Mor et al., 2020) 22. Risk(Charandabi et al., 2022; Dia, Faty, Sall, et al., 2022; Dias et al., 2023; D. Kim et al., 2021; Ning et al., 2022; Xiao et al., 2020) 23. Severity(Bahiru et al., 2023; Begum, 2022; Budiawan et al., 2022; Dia, Faty, Sarr, et al., 2022; Donchenko et al., 2020; Fiorentini & Losa, 2020; Gupta et al., 2022; Jain et al., 2022; Kaliraja et al., 2022; Kandasamy et al., 2021; H. Kim et al., 2022; Kushwaha & Abirami, 2022; Lu et al., 2022; Panda et al., 2023; Paul et al., 2020; Rajkumar et al., 2020; Yassin & Pooja, 2020; Zhang et al., 2022) 24. Status(Mapa, 2019) 25. Types (Jha et al., 2021; Zhao et al., 2020)	Sall, et al., 2022; Fiorentini & Losa, 2020; Gupta et al., 2022; Kandasamy et al., 2021; Panda et al., 2023; Sundari et al., 2023; Zhang et al., 2022) 5. Efficiency Solutions(Alrajhi & Kamel, 2019; Jha et al., 2021; Mane & Rathod, 2022; N & Punithavalli, 2020; Xiao et al., 2020; Yeole et al., 2022; M. H. Yuan & Wu, 2022) 6. Future Planning(Begum, 2022; Budiawan et al., 2022; Dias et al., 2023; Fiorentini & Losa, 2020; Mor et al., 2020; Shaik et al., 2021) 7. Hazard(Ballamudi, 2019; Boo & Choi, 2021; Jain et al., 2022; Joshi et al., 2020; Lazar & Jarir, 2022) 8. Identification(Ballamudi, 2019; Begum, 2022; Dia, Faty, Sall, et al., 2022; Dia, Faty, Sarr, et al., 2022; Joshi et al., 2020; Kushwaha & Abirami, 2022; N & Punithavalli, 2019; Rajkumar et al., 2020; Yassin & Pooja, 2020) 9. Number Reduce(Bahiru et al., 2023; Becker et al., 2020; Charandabi et al., 2022; Chen et al., 2022; Cheng et al., 2019; Dabhade, 2020; Guo et al., 2022; Kaliraja et al., 2022; D. Kim et al., 2021; H. Kim et al., 2022; Mehta et al., 2022; Pachaivannan et al., 2020; Parthiban et al., 2022; Patil et al., 2021; S et al., 2022; Sundari et al., 2023; Xiao et al., 2020) 10. Policy(Bokaba et al., 2022; Jha et al., 2021; Mor et al., 2020; Radzuan et al., 2020; M. H. Yuan & Wu, 2022) 11. Safety Measures(Cheng et al., 2019; Kaliraja et al., 2022; P & M, 2022; Panda et al., 2023; Parthiban et al., 2022; Patil et al., 2021; Sahu et al., 2023; Singh et al., 2020; Zhao et al., 2020)

Approach	Model	Prediction	Benefit
et al., 2023; Venkat et al., 2020; Whasphutthisit & Jitsakul, 2022; Wu & Wang, 2020; Xiao et al., 2020; Yassin & Pooja, 2020; Yeole et al., 2022; M. H. Yuan & Wu, 2022; Zhang et al., 2022; Zhao et al., 2020)	33. Random Forest Classifier (RFC)(Kandasamy et al., 2021) 34. Random Tree (RT)(Fiorentini & Losa, 2020) 35. Recurrent Neural Network (RNN)(Shaik et al., 2021) 36. Scale-reduced Attention based on Graph Convolution Network (SA-GCN)(Ning et al., 2022) 37. Stacked Autoencoder(SAE)(Behura & Behura, 2020) 38. Support Vector Machine (SVM)(Augustine & Shukla, 2022; Bokaba et al., 2022; Kandasamy et al., 2021; Lazar & Jarir, 2022; Mane & Rathod, 2022; Panda et al., 2023) 39. Support Vector Regression (SVR)(Wu & Wang, 2020) 40. Synthetic Minority Over-sampling Technique(SMOTE)(Gupta et al., 2022) 41. Tree Augmented Naïve Bayes (TAN)(H. Kim et al., 2022) 42. Zero Inflated Negative Binomial (ZINB)(Popoola et al., 2019)		12. Trend(Behura & Behura, 2020; Radzuan et al., 2020) 13. Trouble(Borucka et al., 2020)(Alrajhi & Kamel, 2019)(Paul et al., 2020)(Shaik et al., 2021)(Popoola et al., 2019) 14. Variability Number(Boo & Choi, 2021)(Ning et al., 2022)(Singh et al., 2020)(Gorzelańczyk et al., 2022)

The presentation is displayed based on the results of the quotation. The quote approach shows two groups: machine learning and deep learning. Between 2019 and 2023, there will be a significant increase in 2023 with the machine learning approach. The most widely used approaches are machine learning instead of deep learning (Figure 3).

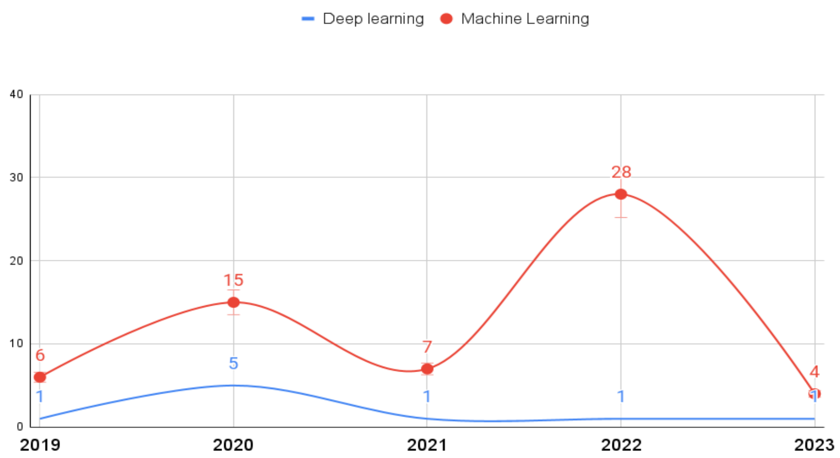

Figure 3. AI in year

The quota model used is 44 models adopted for predicting road accidents. The most used model is random forest, as much as 14.5%, while 29 articles are only used once. Random forest is a popular model used to predict road accidents (Figure 4).

Random Forest is a Machine Learning algorithm used to make predictions in various tasks such as classification and regression. This algorithm is based on ensemble learning, combining several learning models (decision trees) to form a more robust and accurate model. Random Forests are effective in various prediction tasks, but it is important to exercise proper parameter selection and careful model evaluation to achieve optimal performance. Quotation prediction used as many as 26 types of road accident predictions that have been done. Most predictions are as varied as 19 articles with a machine learning approach, while there are as many as 17 types of predictions that do not exist with a deep learning approach (Figure 5).

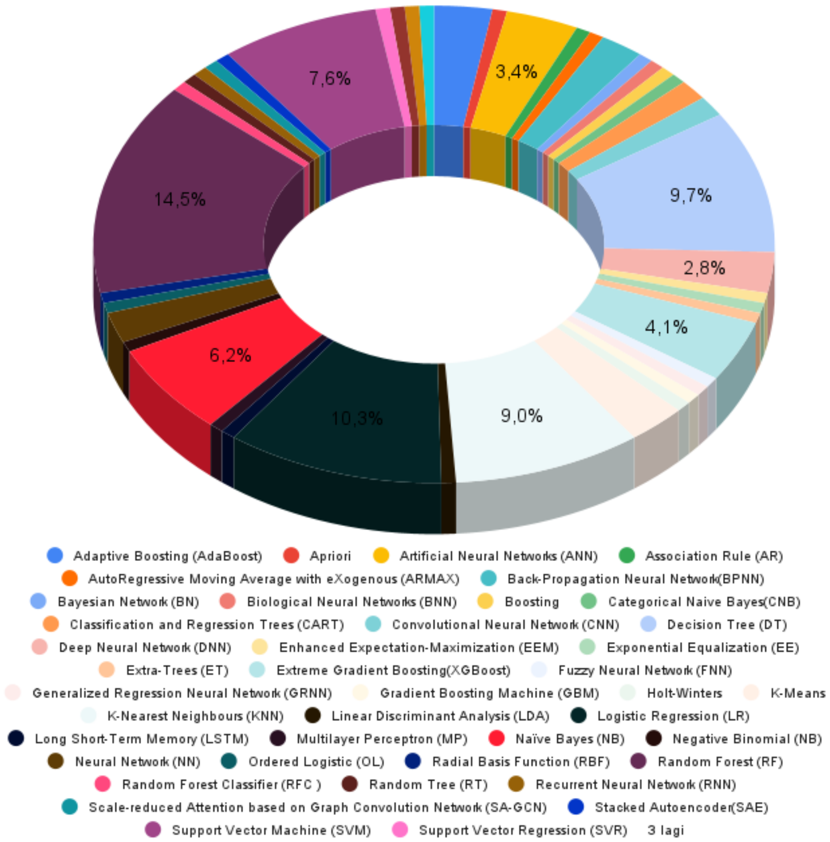

Figure 4. Model prediction using AI

The severity of a road accident refers to the level of impact, including the level of injury or damage caused. It is used to classify accidents into various categories based on the severity of the outcome. The severity of a road accident is usually assessed by considering factors such as the degree of injury suffered by the individuals involved, the extent of property damage, and the possible long-term consequences. Accident severity can be categorized into various levels, often mild to fatal. Determining the severity of a road accident is important for many purposes, such as evaluating the effectiveness of road safety measures, identifying areas of high risk, and informing policies and regulations aimed at reducing accidents and their severity. Accurate assessment of accident severity assists in allocating appropriate resources for emergency response, medical treatment, and rehabilitation of affected individuals. The severity of a road accident can vary significantly based on various factors, including speed, vehicle type, road conditions, driver behavior, and the use of safety measures such as seat belts and airbags. Accurate data collection, analysis, and reporting are critical to understanding trends in accident severity and implementing measures to prevent and reduce road accidents.

Quotation benefits used as many as 14 types of road accident benefits that have been carried out. The most benefits reduce as many as 16 articles with a machine learning approach, while there are as many as five types of benefits that do not exist with a deep learning approach (Figure 6). Number reduction in predicting road accidents refers to efforts to reduce the number of accidents that occur through data analysis and taking appropriate action. This approach is based on data analysis methods to identify risk factors, patterns, and trends related to road accidents and to take preventive measures to reduce the number of road accidents. Number reduction is an approach that aims to reduce the number of road accidents by using data analysis and appropriate preventive measures. By understanding the risk factors and patterns of accidents and implementing appropriate actions, it is hoped that the number of accidents can be reduced and road safety can be increased.

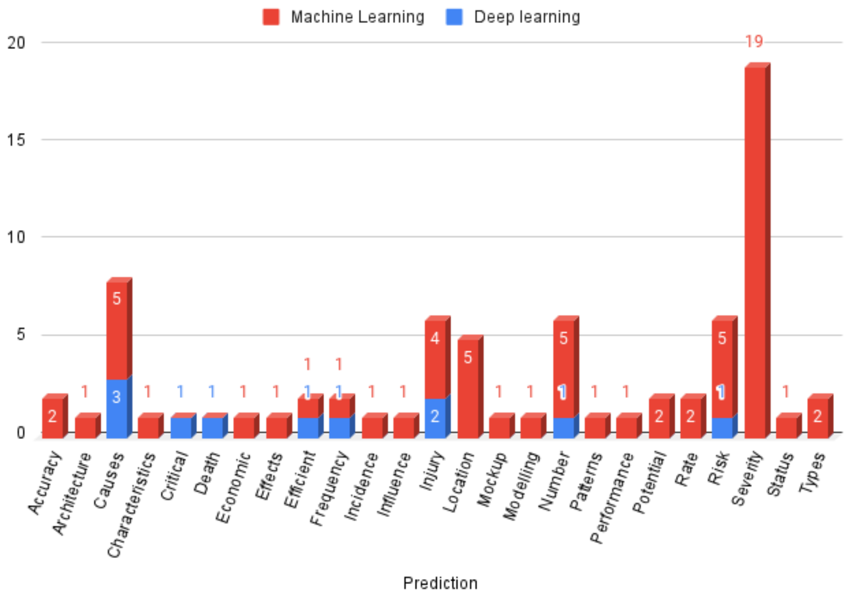

Figure 5. Road accident prediction using AI

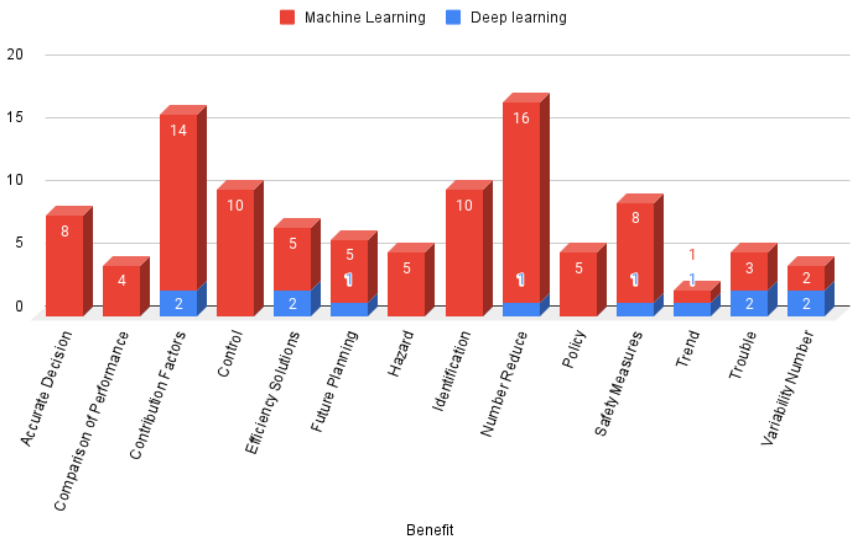

Figure 6. Road accident prediction benefits using AI

The representation is prepared based on the presentation's results about AI's role in predicting road accidents. Road accidents and related factors are the basic things needed to predict accidents as needed. Models and approaches using AI are the main ingredients for making predictions with road accident data and related factors, so strategies and anticipations can be made to overcome them. Strategies and anticipation of road accidents are based on road accident predictions suitable for improving road safety (Figure 7).

AI can play an important role in several aspects of road accident prediction. AI can predict data related to road accidents, such as accident historical data, road conditions, weather, traffic, and other factors.

AI can identify patterns, trends, and risk factors contributing to accidents. The predictions made by AI help in understanding the aspects that influence the occurrence of road accidents. AI can build predictive models to predict future road accidents. Models can consider various factors, such as location, time of day, weather, and road conditions, to predict the probability of an accident in a given area or time. This prediction helps in directing prevention efforts to high-risk areas.

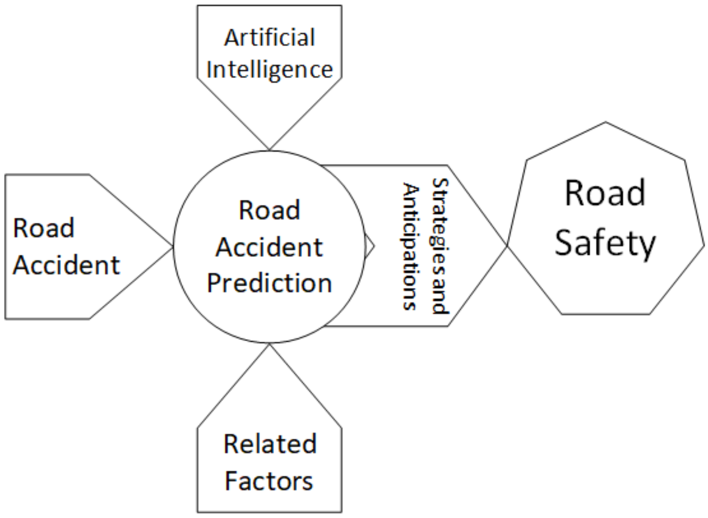

Figure 7. Representation of AI in road accident prediction

AI can help predict risk factors that contribute to road accidents. AI can predict the characteristics of a susceptible driver, environmental factors, road conditions, or the interaction between these factors that impact an accident. This information helps direct prevention efforts to reduce accident risk factors. AI can be used to develop fast and effective accident notification systems. AI uses image and signal processing techniques to predict accidents based on images from traffic cameras or other sensors. This notification system allows for faster emergency response so that assistance can be provided earlier and the impact of an accident can be reduced. AI can optimize traffic management and reduce congestion that can contribute to accidents. Predicting traffic data in real time, AI can identify traffic patterns, predict changes in conditions, and provide recommendations for optimal traffic settings. This helps reduce traffic congestion and improves the smooth movement of vehicles. The representation of the role of AI in predicting road accidents involves data analysis, accident prediction, identification of risk factors, development of accident notification systems, and traffic optimization. Through AI techniques, it is hoped that road accidents can be identified earlier, risk factors can be reduced, and effective preventive measures can be taken to improve road safety.

Road accidents predicted using AI can be explored in more depth in articles that have been published. Astuteness and understanding of AI are very influential when collecting these articles. Quotation is a key process in selecting and sorting the suitability of the articles to be collected. More time, high precision, and understanding between reviewers are the biggest challenges in analyzing the articles used.

CONCLUSION

AI plays a significant role in road accident prediction by collecting and analyzing data, building predictive models, and providing valuable insights. AI can analyze traffic data, weather, road conditions, and other factors potentially influencing accidents. The use of AI in road accident prediction brings great potential to improve road safety, reduce the number of accidents, and optimize emergency response. The results of the presentation can be used as a reference for developing road accident predictions in terms of approach, model, prediction, and benefits. The results of the representation can be used as an illustration to answer demands for road accident predictions that suit your needs with the aim of improving road safety. Data availability, data suitability, and stakeholder support are challenges in making road accident predictions. Preparation of anticipation and strategies can be carried out with stakeholders to predict improvements in road safety in future work.

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References

Alagarsamy, S., Malathi, M., Manonmani, M., Sanathani, T., & Kumar, A. S. (2021). Prediction of road accidents using machine learning technique. *2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA)*, 1695–1701. doi: 10.1109/ICECA52323.2021.9675852

Alrajhi, M., & Kamel, M. (2019). A deep-learning model for predicting and visualizing the risk of road traffic accidents in Saudi Arabia: A tutorial approach. *International Journal of Advanced Computer Science and Applications*, *10*(11). doi: 10.14569/IJACSA.2019.0101166

Augustine, T., & Shukla, S. (2022). Road accident prediction using machine learning approaches. *2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)*, 808–811. doi: 10.1109/ICACITE53722.2022.9823499

Babu, S. N., & Tamilselvi, J. (2019). Generating road accident prediction set with road accident data analysis using enhanced expectation-maximization clustering algorithm and improved association rule mining. *Journal Europeen Des Systemes Automatises*, *52*(1). doi: 10.18280/jesa.520108

Bahiru, T. K., Manjula, V. S., Akele, T. B., Tesfaw, E. A., & Belay, T. D. (2023). Mining road traffic accident data for prediction of accident severity. *2023 International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT)*, 606–612. doi: 10.1109/IDCIoT56793.2023.10053409

Ballamudi, K. R. (2019). Road accident analysis and prediction using machine learning algorithmic approaches. *Asian Journal of Humanity, Art and Literature*, *6*(2), 185–192. doi: 10.18034/ajhal.v6i2.529

Barachi, M. El, Kamoun, F., Ferdaos, J., Makni, M., & Amri, I. (2020). An artificial intelligence based crowdsensing solution for on-demand accident scene monitoring. *Procedia Computer Science*, *170*, 303–310. doi: 10.1016/j.procs.2020.03.044

Becker, N., Rust, H. W., & Ulbrich, U. (2020). Predictive modeling of hourly probabilities for weather-related road accidents. *Natural Hazards and Earth System Sciences*, *20*(10), 2857–2871. doi: 10.5194/nhess-20-2857-2020

Begum, A. P. S. B. (2022). Road accidents prediction and classification. *International Journal for Research in Applied Science and Engineering Technology*, *10*(6), 4488–4491. doi: 10.22214/ijraset.2022.44988

Behura, A., & Behura, A. (2020). Road accident prediction and feature analysis by using deep learning. *2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, 1–7. doi: 10.1109/ICCCNT49239.2020.9225336

Bokaba, T., Doorsamy, W., & Paul, B. S. (2022). Comparative study of machine learning classifiers for modelling road traffic accidents. *Applied Sciences (Switzerland)*, *12*(2). doi: 10.3390/app12020828

Boo, Y., & Choi, Y. (2021). Comparison of prediction models for mortality related to injuries from road traffic accidents after correcting for undersampling. *International Journal of Environmental Research and Public Health*, *18*(11), 5604. doi: 10.3390/ijerph18115604

Boo, Y., & Choi, Y. (2022). Comparison of mortality prediction models for road traffic accidents: an ensemble technique for imbalanced data. *BMC Public Health*, *22*(1), 1476. doi: 10.1186/s12889-022-13719-3

Borucka, A., Kozłowski, E., Oleszczuk, P., & Świderski, A. (2020). Predictive analysis of the impact of the time of day on road accidents in Poland. *Open Engineering*, *11*(1), 142–150. doi: 10.1515/eng-2021-0017

Budiawan, W., Sriyanto, Saptadi, S., Arvianto, A., Pamuji, H., & Andarani, P. (2022). Design of traffic accident prediction model in toll road using a decision tree algorithm. *International Journal of Applied Science and Engineering Review*, *03*(06), 11–31. doi: 10.52267/IJASER.2022.3602

Charandabi, N. K., Gholami, A., & Bina, A. A. (2022). Road accident risk prediction using generalized regression neural network optimized with self-organizing map. *Neural Computing and Applications*, *34*(11), 8511–8524. doi: 10.1007/s00521-021-06549-8

Chen, L., Li, C. Y., Zhan, L., Tan, Q., Tian, X. M., Cheng, H., & Li, K. (2022). Influencing factors analysis and prediction of urban road traffic accident patterns. *Chang'an Daxue Xuebao (Ziran Kexue Ban)/Journal of Chang'an University (Natural Science Edition)*, *42*(4). doi: 10.19721/j.cnki.1671-8879.2022.04.010

Cheng, R., Zhang, M.-M., & Yu, X.-M. (2019). Prediction model for road traffic accident based on random forest. *DEStech Transactions on Social Science, Education and Human Science*, *icesd*. doi: 10.12783/dtssehs/icesd2019/28223

Dabhade, S. (2020). Road accident analysis and prediction using machine learning. *International Journal for Research in Applied Science and Engineering Technology*, *8*(1), 100–103. doi: 10.22214/ijraset.2020.1018

Dia, Y., Faty, L., Sall, O., Tona Landu, T., & Ngor Sarr, E. (2022). Predicting the severity of the road accidents in Senegal: An empirical study. *2022 the 5th International Conference on Data Storage and Data Engineering (DSDE)*, 91–96. doi: 10.1145/3528114.3528129

Dia, Y., Faty, L., Sarr, M. D., Sall, O., Bousso, M., & Landu, T. T. (2022). Study of supervised learning algorithms for the prediction of road accident severity in Senegal. *2022 7th International Conference on Computational Intelligence and Applications (ICCIA)*, 123–127. doi: 10.1109/ICCIA55271.2022.9828434

Dias, D., Silva, J. S., & Bernardino, A. (2023). The prediction of road accident risk through data mining: A case study from Setubal, Portugal. *Informatics*, *10*(1), 17. doi: 10.3390/informatics10010017

Donchenko, D., Sadovnikova, N., & Parygin, D. (2020). Prediction of road accidents' severity on Russian roads using machine learning techniques. In *Lecture Notes in Mechanical Engineering.* 1493–1501. doi: 10.1007/978-3-030-22063-1_157

Farina, E., Nabhen, J. J., Dacoregio, M. I., Batalini, F., & Moraes, F. Y. (2022). An overview of artificial intelligence in oncology. In *Future Science OA* (Vol. 8, Issue 4). doi: 10.2144/fsoa-2021-0074

Fiorentini, N., & Losa, M. (2020). Handling imbalanced data in road crash severity prediction by machine learning algorithms. *Infrastructures*, *5*(7), 61. doi: 10.3390/infrastructures5070061

Franklin, R. J., & Mohana. (2020). Traffic signal violation detection using artificial intelligence and deep learning. *2020 5th International Conference on Communication and Electronics Systems (ICCES)*, 839–844. doi: 10.1109/ICCES48766.2020.9137873

Gangwani, D., & Gangwani, P. (2021). Applications of machine learning and artificial intelligence in intelligent transportation system: A review. In *Lecture Notes in Electrical Engineering* (Vol. 778, pp. 203–216). doi: 10.1007/978-981-16-3067-5_16

Gorzelańczyk, P., Jurkovič, M., Kalina, T., & Mohanty, M. (2022). Forecasting the road accident rate and the impact of the covid 19 on its frequency in the polish provinces. *Communications - Scientific Letters of the University of Zilina*, *24*(4), A216–A231. doi: 10.26552/com.C.2022.4.A216-A231

Guo, Q., Guo, B., Wang, Y., Tian, S., & Chen, Y. (2022). A combined prediction model composed of the GM (1,1) model and the BP neural network for major road traffic accidents in China. *Mathematical Problems in Engineering*, *2022*, 1–11. doi: 10.1155/2022/8392759

Gupta, U., MK, V., & Srinivasa, G. (2022). A comprehensive study of road traffic accidents: Hotspot analysis and severity prediction using machine learning. *2022 IEEE Bombay Section Signature Conference (IBSSC)*, 1–6. doi: 10.1109/IBSSC56953.2022.10037449

Gutierrez-Osorio, C., & Pedraza, C. (2020). Modern data sources and techniques for analysis and forecast of road accidents: A review. *Journal of Traffic and Transportation Engineering (English Edition)*, *7*(4), 432–446. doi: 10.1016/j.jtte.2020.05.002

Huamaní, E. L., Mantari, A. A., Leon-Ayala, R., & Meneses-Claudio, B. (2023). Development of artificial intelligence algorithm for the analysis and prediction of car accidents on the roads of Peru. *International Journal of Engineering Trends and Technology*, *71*(2), 52–60. doi: 10.14445/22315381/IJETT-V71I2P207

Infante, P., Jacinto, G., Santos, D., Nogueira, P., Afonso, A., Silva, M., Nogueira, V., Rego, L., Quaresma, P., Saias, J., Gois, P., & Rebelo Manuel, P. (2023). Prediction of road traffic accidents on a road in Portugal: A mixed artificial intelligence, statistics, and geographic information systems approach. *SSRN Electronic*

Journal. doi: 10.2139/ssrn.4334671

Jain, S., Krishna, S., Pruthi, S., Jain, R., & Nagrath, P. (2022). Analysis of road accidents in India and prediction of accident severity. In *Lecture Notes on Data Engineering and Communications Technologies* (Vol. 71, pp. 69–87). doi: 10.1007/978-981-16-2937-2_6

Jha, A. N., Chatterjee, N., & Tiwari, G. (2021). A performance analysis of prediction techniques for impacting vehicles in hit-and-run road accidents. *Accident Analysis & Prevention*, *157*, 106164. doi: 10.1016/j.aap.2021.106164

Ji, W., Yang, T., Yuan, Q., Cheng, G., & Yu, S. (2023). Prediction model of accident vehicle speed based on artificial intelligence decision tree algorithm. In *Lecture Notes in Electrical Engineering: Vol. 941 LNEE* (pp. 317–324). doi: 10.1007/978-981-19-4786-5_44

Joshi, S., Alsadoon, A., Senanayake, S. M. N. A., Prasad, P. W. C., Yong, S. Y., Elchouemi, A., & Vo, T. H. (2020). Pattern mining predictor system for road accidents. In *Communications in Computer and Information Science* (Vol. 1287, pp. 605–615). doi: 10.1007/978-3-030-63119-2_49

Kaliraja, C., Chitradevi, D., & Rajan, A. (2022). Predictive analytics of road accidents using machine learning. *2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)*, 1782–1786. doi: 10.1109/ICACITE53722.2022.9823773

Kandasamy, S., Akshaya, S., Anush, J., & Arunkumar, S. (2021). A machine learning approach to analyze and predict the severity of road accidents. *Annals of the Romanian Society for Cell Biology*.

Khan, S., Adnan, A., & Iqbal, N. (2022). Applications of artificial intelligence in transportation. *2022 International Conference on Electrical, Computer and Energy Technologies (ICECET)*, 1–6. doi: 10.1109/ICECET55527.2022.9872928

Kim, D., Jung, S., & Yoon, S. (2021). Risk prediction for winter road accidents on expressways. *Applied Sciences (Switzerland)*, *11*(20). doi: 10.3390/app11209534

Kim, H., Kim, J.-T., Shin, S., Lee, H., & Lim, J. (2022). Prediction of run-off road crash severity in South Korea's highway through tree augmented naïve bayes learning. *Applied Sciences*, *12*(3), 1120. doi: 10.3390/app12031120

Kim, Y., Park, J., & Oh, C. (2021). A crash prediction method based on artificial intelligence techniques and driving behavior event data. *Sustainability*, *13*(11), 6102. doi: 10.3390/su13116102

Kshirsagar, P. R., Dadheech, P., Yuvaraj, T., Moorthy, C. A. S., & Upadhyaya, M. (2022). Fatigue detection using artificial intelligence. *AIP Conference Proceedings*, *2393*, 020080. doi: 10.1063/5.0074121

Kumar, B. V., Srinivas, K. K., Anudeep, P., Yadav, N. S., Kumar, G. V., & Harsha Vardhini, P. A. (2021). Artificial intelligence based algorithms for driver distraction detection: A review. *2021 6th International Conference on Signal Processing, Computing and Control (ISPCC)*, *2021-October*, 383–386. doi: 10.1109/ISPCC53510.2021.9609349

Kushwaha, M., & Abirami, M. S. (2022). Comparative analysis on the prediction of road accident severity using machine learning algorithms. *International Conference on Micro-Electronics and Telecommunication Engineering*, *373*, 269–280. doi: 10.1007/978-981-16-8721-1_26

Lazar, H., & Jarir, Z. (2022). Road traffic accident prediction: a driving behavior approach. *2022 8th International Conference on Optimization and Applications (ICOA)*, 1–4. doi: 10.1109/ICOA55659.2022.9934000

Lu, Y., Wu, J., Shao, S., Shi, S., Zhou, R., & Wang, W. (2022). Prediction model for road transport accidents of hazardous chemicals based on Bayesian network. *China Safety Science Journal*, *32*(3). doi: 10.16265/j.cnki.issn1003-3033.2022.03.024

Lv, Z., & Xie, S. (2021). Artificial intelligence in the digital twins: State of the art, challenges, and future research topics. *Digital Twin*, *1*, 12. doi: 10.12688/digitaltwin.17524.1

Mane, G., & Rathod, V. U. (2022). Road accident prediction using machine learning techniques. *International Journal of Research in Engineering and Science (IJRES)*, *10*.

Mapa, J. S. (2019). Road traffic accident case status prediction integrating a modified C4.5 algorithm. *International Journal of Advanced Trends in Computer Science and Engineering*, *8*(5), 2622–2625. doi: 10.30534/ijatcse/2019/114852019

Mehta, K., Jain, S., Agarwal, A., & Bomnale, A. (2022). Road accident prediction using Xgboost. *2022 International Conference on Emerging Techniques in Computational Intelligence (ICETCI)*, 50–56. doi: 10.1109/ICETCI55171.2022.9921367

Meocci, M., Branzi, V., Martini, G., Arrighi, R., & Petrizzo, I. (2021). A predictive pedestrian crash model based on artificial intelligence techniques. *Applied Sciences*, *11*(23), 11364. doi: 10.3390/app112311364

Mor, N., Sood, H., & Goyal, T. (2020). Application of machine learning technique for prediction of road accidents in Haryana-A novel approach. *Journal of Intelligent & Fuzzy Systems*, *38*(5), 6627–6636. doi: 10.3233/JIFS-179742

N, A. P., & Punithavalli, M. (2019). Prediction of road accident locations in road accident database by mining spatio-temporal association rules. *ARPN Journal of Engineering and Applied Sciences*, *14*(12).

N, A. P., & Punithavalli, M. (2020). Bounded memory based frequent pattern growth approach with deep neural network and decision tree for road accident prediction. *Indian Journal of Computer Science and Engineering*, *11*(5), 623–633. doi: 10.21817/indjcse/2020/v11i5/201105189

Ning, J., She, H., Zhao, D., Luo, D., & Wang, L. (2022). A road-level traffic accident risk prediction method. *Beijing Youdian Daxue Xuebao/Journal of Beijing University of Posts and Telecommunications*, *45*(2). doi: 10.13190/j.jbupt.2021-142

Olayode, O. I., Tartibu, L. K., & Okwu, M. O. (2020). Application of artificial intelligence in traffic control system of non-autonomous vehicles at signalized road intersection. *Procedia CIRP*, *91*, 194–200. doi: 10.1016/j.procir.2020.02.167

Olugbade, S., Ojo, S., Imoize, A. L., Isabona, J., & Alaba, M. O. (2022). A review of artificial intelligence and machine learning for incident detectors in road transport systems. *Mathematical and Computational Applications*, *27*(5), 77. doi: 10.3390/mca27050077

Oueida, S., Hossain, S. Q., Kotb, Y., & Ahmed, S. I. (2022). A fair and ethical healthcare artificial intelligence system for monitoring driver behavior and preventing road accidents. In *Lecture Notes in Networks and Systems: 359*. 431–444. doi: 10.1007/978-3-030-89880-9_33

P, C., & M, S. (2022). Road accident prediction and classification using machine learning. *2022 IEEE 2nd Mysore Sub Section International Conference (MysuruCon)*, 1–8. doi: 10.1109/MysuruCon55714.2022.9972671

Pachaivannan, P., Hemamalini Ranganathan, R., Navin Elamparithi, P., & Dhanagopal, R. (2020). Indian road conditions and accident risk predictions using deep learning approach – A review. *2020 3rd International Conference on Intelligent Sustainable Systems (ICISS)*, 199–202. doi: 10.1109/ICISS49785.2020.9316128

Panda, C., Mishra, A. K., Dash, A. K., & Nawab, H. (2023). Predicting and explaining severity of road accident using artificial intelligence techniques, SHAP and feature analysis. *International Journal of Crashworthiness*, *28*(2), 186–201. doi: 10.1080/13588265.2022.2074643

Parthiban, D., Vijayan, D. S., Shadhil, M. H., Reshma, U., & Krishnan, R. (2022). Analysis of road accident with prediction model using machine learning algorithm in the region of Kerala. *AIP Conference Proceedings*, *2426*, 020009. doi: 10.1063/5.0111414

Patil, J., Patil, V., Walavalkar, D., & Lobo, V. B. (2021). Road accident analysis and hotspot prediction using clustering. *2021 6th International Conference on Communication and Electronics Systems (ICCES)*, 763–768. doi: 10.1109/ICCES51350.2021.9489074

Paul, J., Jahan, Z., Lateef, K. F., Islam, M. R., & Bakchy, S. C. (2020). Prediction of road accident and severity of Bangladesh applying machine learning techniques. *2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC)*, *2020-Decem*, 1–6. doi: 10.1109/R10-HTC49770.2020.9356987

Popoola, O. M., Abiola, O. S., Odunfa, S. O., & Ismaila, S. O. (2019). Comparison of road traffic accident prediction models for two-lane highway integrating traffic and pavement condition parameters. *Journal of Natural Sciences Engineering and Technology*, *16*(2), 1–10. doi: 10.51406/jnset.v16i2.1841

Prakash, T. D., & V, N. (2022). Comparative analysis using K-Nearest neighbour with artificial neural network to improve accuracy for predicting road accidents. *2022 International Conference on Edge Computing and Applications (ICECAA)*, 1092–1096. doi: 10.1109/ICECAA55415.2022.9936227

Radzuan, N. Q., Hassan, M. H. A., Abdul Majeed, A. P. P., Musa, R. M., Mohd Razman, M. A., & Abu Kassim, K. A. (2020). Predicting serious injuries due to road traffic accidents in Malaysia by means of artificial neural network. In *Lecture Notes in Mechanical Engineering* (pp. 75–80). doi: 10.1007/978-981-13-9539-0_8

Rajkumar, A. R., Prabhakar, S., & Priyadharsini, A. M. (2020). Prediction of road accident severity using machine learning algorithm. *International Journal of Advanced Science and Technology*, *29*(6).

S, S., J, A. B., D, V., D, M. G., & Anusha. (2022). Road accident analysis and prediction model using a data mining hybrid technique. *International Journal for Research in Applied Science and Engineering Technology*, *10*(7), 4300–4304. doi: 10.22214/ijraset.2022.45977

Sahu, S., Maram, B., Gampala, V., & Daniya, T. (2023). Analysis of road accidents prediction and interpretation using KNN classification model. In *Lecture Notes in Networks and Systems*. 490, pp. 163–172). doi: 10.1007/978-981-19-4052-1_18

Shaheen, M., Arshad, M., & Iqbal, O. (2020). Role and key applications of artificial intelligence & machine learning in transportation. *European Journal of Technology*, *4*(1), 47–59. doi: 10.47672/ejt.632

Shaik, M. E., Islam, M. M., & Hossain, Q. S. (2021). A review on neural network techniques for the prediction of road traffic accident severity. *Asian Transport Studies*, *7*, 100040. doi: 10.1016/j.eastsj.2021.100040

Singh, G., Pal, M., Yadav, Y., & Singla, T. (2020). Deep neural network-based predictive modeling of road accidents. *Neural Computing and Applications*, *32*(16), 12417–12426. doi: 10.1007/s00521-019-04695-8

Sundari, M. R., Reddi, P., Murthy, K. S., & Sowmya, D. S. (2023). Fatality prediction in road accidents using neural networks. In *Lecture Notes in Networks and Systems* (Vol. 600, pp. 25–33). doi: 10.1007/978-981-19-8825-7_3

Tonni, S. I., Aka, T. A., Antik, M. M., Taher, K. A., Mahmud, M., & Kaiser, M. S. (2021). Artificial intelligence based driver vigilance system for accident prevention. *2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD)*, 412–416. doi: 10.1109/ICICT4SD50815.2021.9396916

Venkat, A., Vijey, G. K., & Susan Thomas, I. (2020). Machine learning based analysis for road accident prediction. *International Journal of Emerging Technology and Innovative Engineering*, *6*(2).

Whasphutthisit, T., & Jitsakul, W. (2022). Comparison of prediction models for road deaths on road network. *2022 14th International Conference on Knowledge and Smart Technology (KST)*, 137–142. doi: 10.1109/KST53302.2022.9729086

Wu, D., & Wang, S. (2020). Comparison of road traffic accident prediction effects based on SVR and BP neural network. *2020 IEEE International Conference on Information Technology,Big Data and Artificial Intelligence (ICIBA)*, 1150–1154. doi: 10.1109/ICIBA50161.2020.9277150

Xiao, Z., Tian, Y., Cao, D., & Zhang, Z. (2020). Road traffic risk safety prediction based on BP neural network. *2020 IEEE 9th Joint International Information Technology and Artificial Intelligence Conference (ITAIC)*, 527–533. doi: 10.1109/ITAIC49862.2020.9339063

Yassin, S. S., & Pooja. (2020). Road accident prediction and model interpretation using a hybrid K-means and random forest algorithm approach. *SN Applied Sciences*, *2*(9), 1576. doi: 10.1007/s42452-020-3125-1

Yeole, M., Jain, R. K., & Menon, R. (2022). Prediction of road accident using artificial neural network. *International Journal of Engineering Trends and Technology*, *70*(2), 143–150. doi: 10.14445/22315381/IJETT-V70I2P217

Yeole, M., Jain, R. K., & Menon, R. (2023). Road traffic accident prediction for mixed traffic flow using artificial neural network. *Materials Today: Proceedings*, *77*, 832–837. doi: 10.1016/j.matpr.2022.11.490

Yuan, M. H., & Wu, Y. F. (2022). A gray prediction method for economic loss of road traffic accidents based on Logistic model. *Advances in Transportation Studies*, *4*(Special issue). doi: 10.53136/97912218027646

Yuan, Y., Yi, A., Wang, Y., & Chen, X. (2021). Research on technical model and method of urban road traffic accident and traffic conflict based on artificial intelligence. *2021 International Conference on Aviation Safety and Information Technology*, 885–889. doi: 10.1145/3510858.3511416

Zhang, C., Li, Y., & Li, T. (2022). A road traffic accidents prediction model for traffic service robot. *Library Hi Tech*, *40*(4), 1031–1048. doi: 10.1108/LHT-05-2020-0115

Zhao, F., Fu, L., Zhong, M., Cui, G., & Zheng, C. (2020). Traffic accident prediction on provincial road using fuzzy neural network. *CICTP 2020*, 3959–3968. doi: 10.1061/9780784482933.340